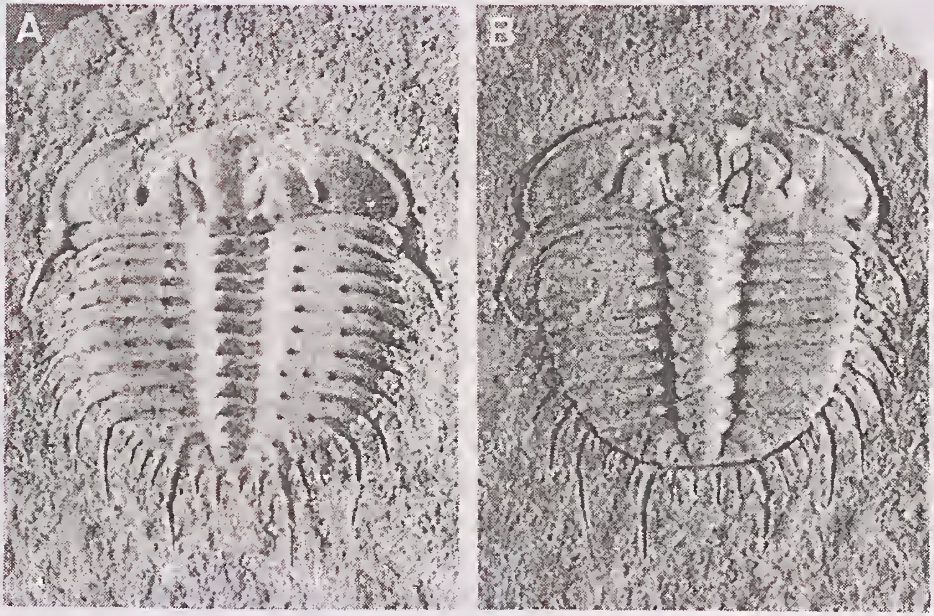
THE FOSSIL COLLECTOR

BULLETIN No. 55 SEPTEMBER 1998



Early Silurian trilobite *Sinespinaspis* sp. from Cotton Hill Quarry, Forbes, New South Wales. A, external mould; B, internal cast (x4.4).

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THE FOSSIL COLLECTORS' ASSOCIATION OF AUSTRALASIA

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EDITORIAL NOTES

By the time most people read this issue of *The Fossil Collector* I will have more than likely finished my 'long' field trip for 1998. As I am writing this editorial some six weeks before the actual date I am due to leave, I will not mention too much about where we are going or what we might find, for fear of incurring the wrath of whatever power it is that would make it rain in the areas we will be visiting. Northern and western Queensland are our targets for this year. I will write a longer account of our trip and what we did (and didn't) find in the January 1999 issue.

The weekend of July 10-12 saw a group of us head out to Chinchilla to collect from the Plio-Pleistocene vertebrate localities which can be found in the area and I have to report that we all had a terrific time and collected some fantastic material (and this is coming from a mainly invertebrate collector). The area we collected from is a largely untouched locality and hence the fossil material is plentiful and in very good condition. We found an abundance of crocodile teeth and to a lesser extent, macropod and diprotodontid teeth. Also to be found were bones from macropods, diprotodontids, crocodile, wombatids, varanids, small reptiles and what we believe may be some bird bones (very late news indicates that we may also have a new possum as well). The find of the weekend was made by a visiting American friend (and now subscriber to *The Fossil Collector*) Jewel Pozefsky who found some lungfish teeth, Jewel was able to make a mould of these teeth so that she can show it to the palaeontological club she is a member of back in Florida. My find of the weekend was a wombatid? limb bone which is about 25 cms long and around 98% complete and although it is crushed at one end, proper identification will be fairly easy. The bone also taught me some new skills in the collection of fossils, that of patience, collecting invertebrates is so much more easy when compared to these bones. The patience came from the fact that the bone was doing its best to fall apart as the dirt surrounding it was removed, so it was a case of remove a little dirt then consolidate the bone with some paraloid then move on to the next section. All up the bone took me about four hours to remove and even though it did come out in three pieces, I am happy to say the pieces are large and the bone will be easy to glue together after some more preparation. We will hopefully be visiting this area again before the end of winter as we are sure there must still be some important material to be found.

This issue sees Part 2 of Dr. Ralph Molnar's series on identifying fossil mammal teeth and I have to say that these articles have already been of assistance to me in identifying some of the teeth I bought home from the Chinchilla trip. At this time, I would like to thank Ralph for taking the time to prepare this series of articles for all the readers of *The Fossil Collector* and also the artist for the series, Chris Glen, who I feel has done a wonderful job at artistically reproducing the specimens used in the series (I am only jealous because my artistic talents have not progressed beyond that of stick figures).

Also in this issue is my first ever attempt at writing an article for this publication, it is on the Green River Formation of Utah and Wyoming in the U. S. A. and some of the fossils that can be found there. I would ask that readers go a little easy on me with this article as editing is one thing but writing is by far a different kettle of fish and it is not really something I am good at. As this issue is a little challenged on the quantity side of things it became necessary for me to do some quick thinking and this article is it.

As I missed the opportunity in the last bulletin, I will mention that this issue is the eleventh since I took on the job of editor (yes, I missed the tenth) and I must say that I am still enjoying the job and have every intention of continuing it until either the F.C.A.A. can no longer exist due to lack of membership or material to print in *The Fossil Collector* becomes non-existent. As the editor, it is my job here to argue that it will be the latter as this is what all editors are good at doing ☺. I realise I have allowed the technical quality of *The Fossil Collector* to slip a little since taking on the job of editor, this is something I hope to be able to remedy over the next few issues.

As this is also the issue before Christmas, Julie, Ayla and I would like to wish all readers and their families a very safe and happy Christmas and enjoyable New Year.

The deadline for the next issue, Bulletin 56, is Friday November 6, 1998.

If readers have an E-mail address and would like it included in the *Directory of Subscribers*, which is published once per year, please contact the Secretary/ Treasurer or myself with your details so that they can be included in the directory.

RECOGNISING FOSSIL MAMMAL TEETH
Part 2

Ralph Molnar. Queensland Museum, P.O. Box 3300 South Brisbane, Qld. 4101.
Base Drawings. Chris Glen. P.O. Box 399 Noosa,Qld. 4567 & R. Molnar.

INTRODUCTION

There are mammals other than bandicoots and dasyurids, in fact, most fossil mammal teeth in Australia don't come from these animals. Bandicoots and dasyurids are rather small mammals, and of course there are fewer carnivorous forms than plant eaters, so for both these reasons dasyurid and bandicoot teeth are not readily found fossils. They can indeed be found but they often require special searching or special techniques, like sieving.

Teeth of the bigger plant eaters are much more common, these include the kangaroos (macropods) and, especially, the large diprotodonts. Notice that the term diprotodont is used in two distinct ways for fossil mammals. The marsupials, as a whole, used to be divided into two major groups, those with two large, prominent (upper) incisors, called diprotodonts - diprotodon deriving from the Latin for 'two front teeth' - and those with three or four incisors, all more or less the same size, these were called polyprotodonts ('many front teeth'). This usage is clear enough, but it was complicated because the largest of the diprotodont marsupials had been named *Diprotodon.* So the word diprotodont could refer to this single genus, to the animals closely related to those of this genus (in the same family) or to all those marsupials with two enlarged incisors (which also include kangaroos). We will call the genus *Diprotodon* a member of the family diprotodontids, and those more closely related to *Diprotodon* than, say to kangaroos, diprotodontans. Incidentally, the taxonomic division of marsupials into diprotodonts and polyprotodonts is no longer used as such.

DIPROTODONTANS

Diprotodontans were the largest of the marsupials, so it is no surprise that their teeth were large. The molars are also easy to recognise, at least if they are more or less complete and not broken. Upper and lower molars are pretty much the same in form, both have two large transverse crests, known as lophs (technically speaking,

those on the lower molars are lophids). The combination of large size and two lophs marks out diprotodont molars, and makes them casy to recognise, those of *Diprotodon* are specifically characterised by being the largest.

This form of molar, with two lophs, was known in Europe as being characteristic of an extinct group of elephants, the deinotheres. Deinotheres were unusual as elephants in that the lower, rather than the upper, incisors were developed into tusks. When the first teeth of *Diprotodon* went to England, in the 1840's, they were taken to be the teeth of an Australian elephant, a deinothere

Figure 1 shows the molars of *Diprotodon* where the lophs are not worn. When chewing, the teeth are moved past each other in a fore-to-aft fashion (and back again), so the lophs cut up the plant material as they moved across each other. In old individuals, however, and in those that fed on gritty or abrasive vegetation, the molars became worn, and in some cases very worn. The amount of wear can reveal both the age of the individual and whether fresh fodder was available or just dry plant material picked up from the ground, including sand and grit. Worn molars usually still retain the bases of the lophs and so can be recognised (Figure 1).

The premolars are rather smaller than the molars, and roughly triangular in occlusal view, the different species (probably) can be distinguished by the forms of their premolars. These are actually the third premolars, but the anterior two have been lost. We will look at some of the premolars, just to show what diprotodont premolars look like, but premolars are found much less often than the molars.

There were several different kinds of diprotodontans during the Pliocene and Pleistocene, of which the Pleistocene *Diprotodon*, at about 1-2 tonnes, is the largest. But because the taxonomic relationships of the diprotodontans remain unstudied (or, anyway, unpublished) and because the consensus is that many of the current names are incorrect, we shan't - indeed, can't - go into how the diprotodontids differ from one another. Suffice it to say that although *Diprotodon* is the largest diprotodontid, there are also small species of *Diprotodon*. However, the upper premolar of Diprotodon has a U-shaped pattern of crests, when unworn, this is distinctive, so can be used to recognise *Diprotodon*, large or small.

Finally, since the origin of the lophs remains unknown, they may have originated

in at least two ways (given in Archer, 1984), the identification of the cusps given here (Figure 2) shouldn't be taken too seriously.

There is another kind of diprotodontan that has not been mentioned, these are the palorchestids, and these are found less often than forms like *Diprotodon*. For reasons that will become apparent, we will discuss these after the kangaroos.

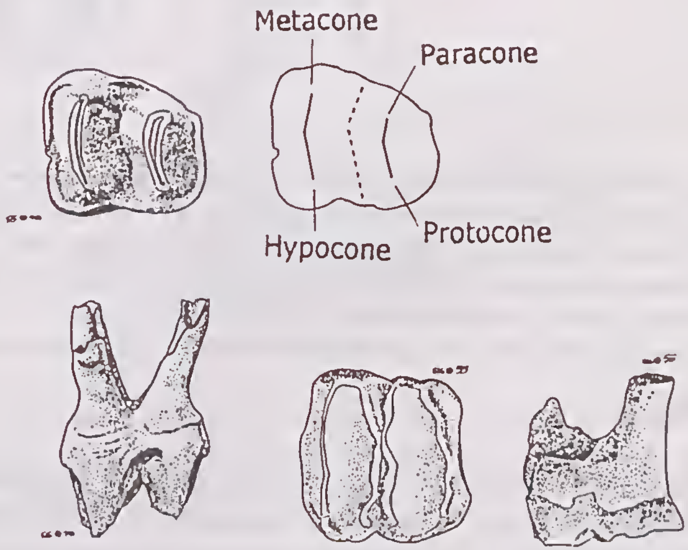

Figure 1. Two molars of diprotodontans. The unworn molar at left top and bottom is that of *Euryzygoma dunense*, and the worn molar at bottom middle and right is that of *Diprotodon optatum*. Both are based on Queensland Museum specimens, but unfortunately the museum did not have a sufficiently well preserved toothrow in either a skull or jaw to draw. The characteristic and easily recognisable double lophs can be easily seen in the *Euryzygoma* tooth, this tooth may be the last (fourth) upper. Even when worn, as in the *Diprotodon* tooth, they are pretty obvious. The upper and lower molars of diprotodontans are very similar, and - since these are isolated teeth - it isn't clear whether they were uppers or lowers. Incidentally, diprotodontan teeth seem often to be more worn than fossil kangaroo teeth, suggesting that the diprotodontans lived to older ages and suffered less risk of dying young, than kangaroos. Not to scale.

Figure 2. Diprotodontan premolars; a complete premolar of *Diprotodon*, centre top and bottom, and a worn premolar of *Zygomaturus*, right top and bottom, both are based on Queensland Museum specimens. The diagram shows the ridges and cusps, but the identifications will be discussed in a later part of this series. These premolars are quite different from those of kangaroos, as shown in Figs. 3 & 4.

KANGAROOS

Kangaroo (macropodid) molars look roughly like those of diprotodonts, but are smaller. The Pliocene and Pleistocene forms show a similar pattern of two transverse lophs, but the lophs are joined by a lower ridge, known as the crosslink or midlink (Figure 3). The teeth of other marsupials do not have crosslinks, although in diprotodonts a ridge projects from the hypoconid diagonally toward the metaconid, which it doesn't reach (this ridge is technically termed the crista obliqua, the oblique crest). In the specimens of *Protemnodon anak* used for Figures 3 and 4, the teeth at the back of the tooth rows in each are unworn whilst those at the front have been worn. This is because the molars at the front erupt before those at the back, that just behind the premolar first, then that adjacent to it, etc., until the rear one erupts last, so the front molars have been exposed to wear for a longer period. In the lower jaw, the last molar, in fact, had not yet erupted when the animal died, thus one can tell that both the animal from which the upper teeth are derived was probably a young adult and that from which the lower jaw was found had not reached maturity. Teeth can tell us more about mammals than simply which they are.

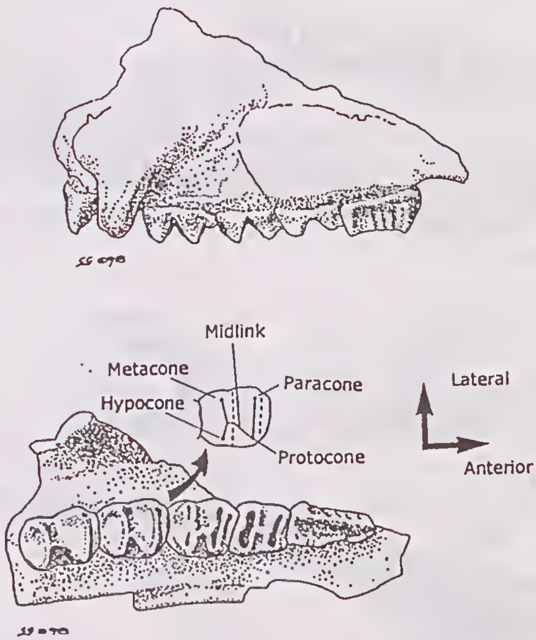

Figure 2. The upper teeth of a fossil macropodine kangaroo, *Protemnodon anak*, based on a specimen in the Queensland Museum. One of the unworn molars (the third) is diagrammed to show the prominent features. Positions of the major cusps are marked by dots, major ridges (lophs) by thick lines, minor ridges by thin lines and 'valleys' by dashed lines. As in Part 1, the toothrow is shown in both lateral (above) and occlusal (below) views. Both upper and lower molars are characterised by having two parallel, transverse ridges, these ridges are joined by the (roughly) transverse midlink (or crosslink). The upper molars resemble those of diprotodontans, in having two prominent transverse ridges, but they differ in the crosslink, and are smaller than the molars of any Plio-Pleistocene diprotodontan. Note the premolar at the right. Not to scale.

Kangaroo (macropod) species, like diprotodont species, are often distinguished on their premolars, not their molars. The teeth of more primitive macropods - betongs and potoroos among others - are more similar in form to those of possums and koalas (to be discussed in Part 3). The molars of early kangaroos, such as those from Riversleigh, haven't (yet) developed a crosslink, and look much like very small diprotodont teeth.

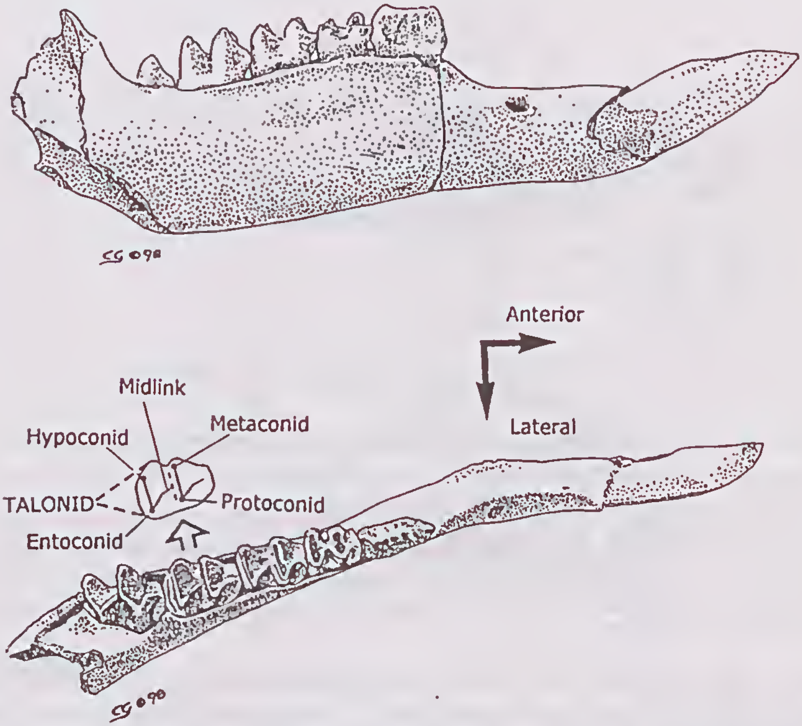

Figure 4. The lower teeth of the macropodine kangaroo, *Protemnodon anak*, based on another specimen in the Queensland Museum. The layout of the drawing and features diagrammed are as in Fig. 3. The lowers differ from the uppers (and those of diprotodontans) in having a distinct cingulum in front of the anterior loph. (this is clearly shown in the figure but not labeled: it is labeled in Fig. 6.) The basic form of the crown, two lophs joined by the midlink, is shown in the diagram of the third molar. Note the premolar at the right of the toothrow, and the incisor at the front of the jaw. Not to scale.

The Plio-Pleistocene macropods come in to groups, the macropodines (grazing kangaroos) and the sthenurines (browsing kangaroos). *Protemnodon anak* is a macropodine as are all modern kangaroos, the sthenurines have all become extinct (well maybe, Tim Flannery thinks that *Lagostrophus*, the Banded Rat Kangaroo, is a surviving relative of the sthenurines). Sthenurines, the later ones at any rate, tended to have deep snouts and some had quite short skulls, almost as deep as they were long, they also developed only a single toe in their hind feet. The sthenurines

were the biggest kangaroos, *Procoptodon* reached a height of three meters.

In terms of teeth, those of sthenurines were like the teeth of macropodines, but with ‘frills’ added (Figures 5&6), there were the same two parallel, transverse lophs, and crosslink, but in addition there were ridges on the lophs, mostly on the backs. These looked like a bad case of wrinkles on the unworn molars and formed little loops and bands on worn teeth.

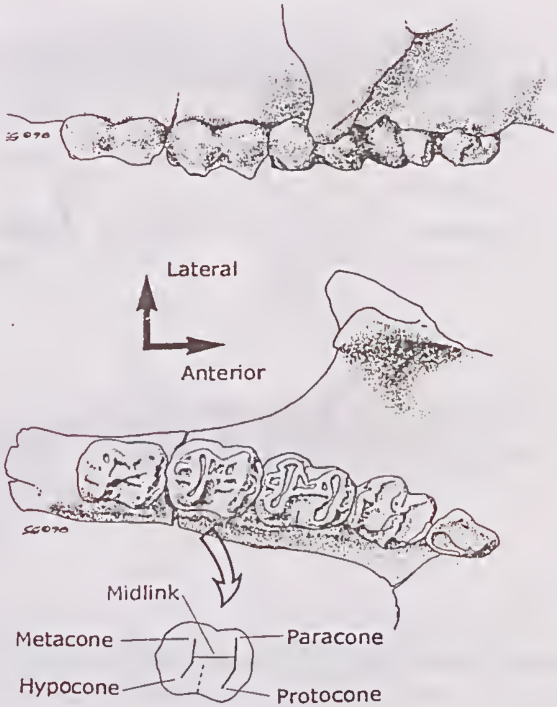

Figure 5. The cheek teeth of the sthenurine kangaroos were different from those of macropodine kangaroos such as *Protemnodon*. The teeth in this figure of the upper teeth of the sthenurine *Procoptodon pusio* (based on a QM specimen). The much more intricate or ornamented form of the molars is clearly seen here, especially lateral to the midlink. The teeth appear more bulbous than those of macropodines and the lophs are less obvious in lateral view, the last molar (left) is almost entirely unworn, with only a little wear at the cusps. The teeth become more worn towards the front (right), with considerable wear on the first molar and premolar. Not to scale.

In basic form, sthenurine molars are like those of macropodines, but they have these extra structures giving them a more ornate form, also, their molars have a more bulbous, rounded appearance. When the lophs of sthenurines are worn, the worn surface has a slightly figure 8 shape, unlike those of macropodines.

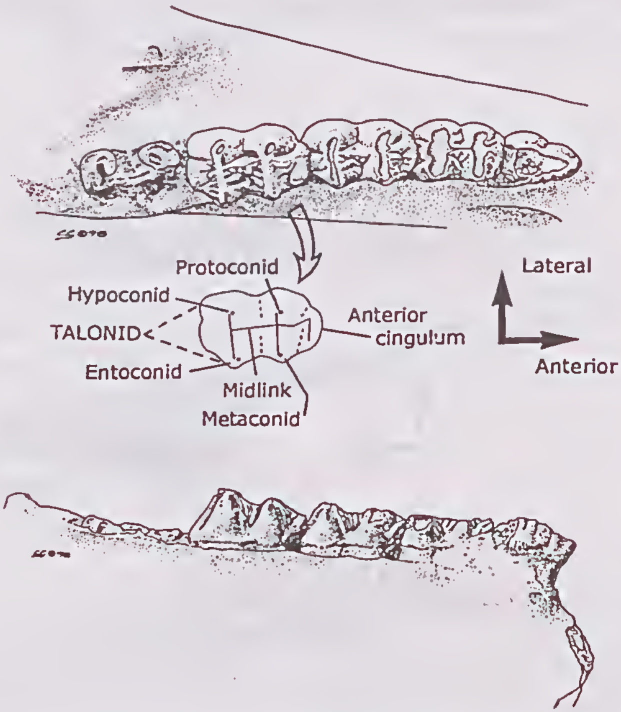

Figure 6. The lower cheek teeth of a related sthenurine, *Procoptodon rapha* (based on a QM specimen). Here, too, the bulbous and more intricate form of the molars is clear, the last molar (left) is broken, with the crown lost entirely, only the broken surface of the roots is seen, the next molar is almost unworn. As in Fig.5, the teeth become more worn towards the front (right). Not to scale.

PALORCHESTIDS

There is only a single palorchestid in the Pliocene and Pleistocene of Australia, *Palorchestes* itself, although there were several earlier genera. The teeth of *Palorchestes* have double lophs, like those of diprotodontans, but also midlinks (Figure 7) like those of kangaroos, thus, it is no surprise that when they were

discovered, they were taken to be the teeth of giant kangaroos. This was reflected in their name *Palorchestes*, 'the leaping one of ancient times', this might seem inappropriate, but since a name is a name, a label, any name (that's polite) is equally appropriate: just as long as it doesn't apply to two different organisms. It wasn't until the discovery of post-cranial remains that it was realised that *Palorchestes* was a quadruped and not a kangaroo. Palorchestids were unusual animals, with large claws and a snout that suggests they may have had a short trunk, like that of a tapir.

Palorchestid teeth are basically like those of (other) diprotodontans, but with a midlink, they lack the ornament of sthenurine molars and are larger than macropodine molars.

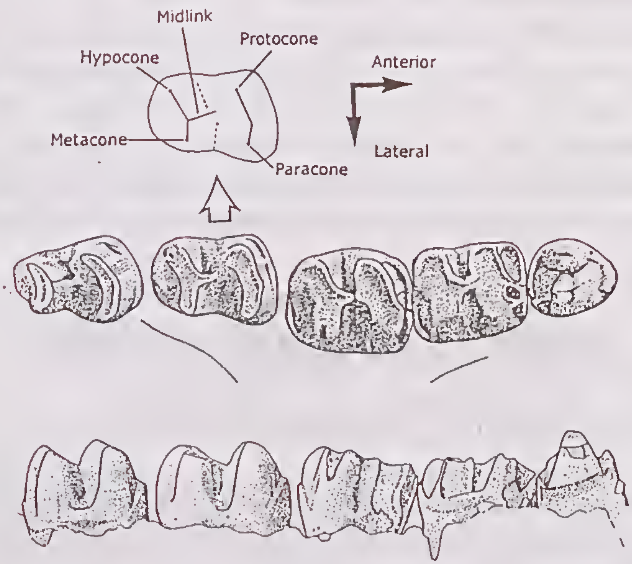

Figure 7. The upper (cheek) teeth of *Palorchestes azael* from a QM specimen (here drawn from a cast. The reason why these teeth were first thought to be from a giant kangaroo can be seen. Like those of kangaroos, they have the two prominent lophs joined by a crosslink, note that the premolar (at the right end of the toothrow), however, is quite different from that of *Protemnodon anak* (in Fig. 3). The teeth at the back of the toothrow (left) have little wear, but they are increasingly worn toward the front (right), and the first two molars are broken laterally. This specimen - the bone not the teeth - is slightly crushed, so that the toothrow is offset between the second an third molars. Not to scale.

The next installment will look at wombat, possum and koala teeth. These can all be found in most Pliocene and Pleistocene fossil deposits but their smaller size makes them more rare than diprotodontan and macropod teeth.

Suggested Further Reading

Archer, M., 1984. The Australian marsupial radiation, in, M. Archer, & G. Clayton, eds., *Vertebrate Zoogeography & Evolution in Australasia.* (Hesperian Press: Carlisle), 633-808 pp. (p. 683).

Archer, M., & Clayton, G., eds., 1984. *Vertebrate Zoogeography & Evolution in Australasia.* (Hesperian Press: Carlisle), 1203 pp. The chapters on mammals, especially 6,7 give much valuable information on mammal teeth.

Rich, T. H., 1991. Monotremes, placentals and marsupials: their record in Australia and its biases. In, P. Vickers-Rich, J. M. Monaghan, R. F. Baird, T. H. Rich, E. M. Thompson & C. Williams, eds., *Vertebrate Palaeontology of Australasia.* (Monash University Publications Committee: Clayton), pp. 893-1004. Good pictures of the teeth of many fossil mammals, and also some information on the teeth of introduced mammals.

BOOKS AND BOOK REVIEWS

PATHWAYS TO THE PAST: FLEURIEU PENINSULA

The South Australian Division of the Geological Society of Australia has produced an A2 (folded) coloured pamphlet illustrating thirteen sites of geological interest on the Fleurieu Peninsula, South Australia.

Although it includes only one major fossil locality, Blanche Point, the pamphlet will be of considerable interest to visitors to the area who wish to see the geological heritage and beautiful scenery along this section of the Gulf of St Vincent and Encounter Bay coastline, south of Adelaide.

The S.A. Division of the G.S.A. are to be congratulated on the production of the pamphlet, although it is a pity that there are spelling errors in the taxonomic names

of two fossils, the bivalve *Pycnodonte* (*Phygraea*) *tarda* (Hutton) and the echinoid *Echinolampas posterocrassa* (Gregory).

Copies of the pamphlet can be obtained from the Secretary, S.A. Division of the Geological Society of South Australia, P.O. Box 211 Fullarton, S.A. 5063, for $2.00 plus 45c. postage; or alternatively from the State Information Centre at 77 Grenfell Street, Adelaide and the S.A. Museum on North Terrace. On the Peninsula they are available from Tourist Information Centres at Victor harbour, Goolwa, McLaren Vale and Mount Lofty Summit.

Frank Holmes.

DINOSAURS OF AUSTRALIA AND NEW ZEALAND and other animals of the Mesozoic Era. by John Long. Published by University of New South Wales Press Ltd, Sydney, August 1998, 188 pp. ISBN 0-86840-448-9 (Hardback), Recommended Retail Price $45.00.

This book is the first to comprehensively review and illustrate every known species of dinosaur, pterosaur, marine reptile, bird, mammal and amphibian that lived in Australia and New Zealand during the age of the dinosaurs.

A full review will be given in the January, 1999 issue of *The Fossil Collector*.

TREATISE ON INVERTEBRATE PALEONTOLOGY, PART L, MOLLUSCA 4 (REVISED). VOLUME 4: CRETACEOUS AMMONOIDEA. C. W. Wright with J. H. Callomon and M. K. Howarth, edited by R. L. Kaesler. The Geological Society of America, Boulder, Colorado and the University of Kansas, Lawrence, Kansas, 1996, 362 pp. ISBN 0-8137-3112-7 (Hardback). Available from Geological Society of America, Boulder, Colorado 80301-9140, U. S. A. Approximate price US$75 (about AUS$120.00).

It is over forty years since the publication of the original single part *Treatise* covering the Ammonoidea by W. J. Arkell *et al.* (1957). That work has been undergoing expansion and revision to four volumes, including an Introduction, Palaeozoic and Triassic, and Jurassic parts. The final volume covering the Cretaceous ammonites is the first to be published. This welcome study should be used in conjunction with the original volume for the introductory sections until the revised first volume of Mollusca 4 becomes available.

LEARNING TO READ A GEOLOGICAL MAP

AGSO's Geoscience Awareness Unit has produced 'An introduction to geological maps' (by Gary Lewis and Julie Guenther; *Record 1998/1*) for university students studying an introductory geoscience course and for the general public. With the aid of an accompanying 1:75,000 scale full colour geological map of the Mount Todd region (NT), which is complemented by a full colour topographical map of the same area at the same scale on its reverse side, the text of this publication explains the significance of the elements reproduced on the geological map sheet - namely:

• the map itself, including
-the application of map projection and scale, and
-the meaning and value of latitudinal, longitudinal and directional expressions;

• the legend, including
-a summary of the rock types referred to and their grouping in the three main rock classes,
-stratigraphic and chronological perspectives of the map units, and
-the meaning, with an expanded explanation as appropriate, of each of the map symbols;

• the geological reliability diagram, including the geologists' contributions to the categories of reliability;

• the cross section, and how it completes a synthesis of the geology of an area presented on the map face; and

• the rock relationship diagram.

Apprised of this basic information, people can begin to read a geological map. The text of *Record 1998/1* promotes this process by presenting explanations of geological structures - how they are reflected in the outcrop depicted on the map, and how weathering and erosion can mould their landforms - and the relationships between mineral deposits identified on the map and the surrounding geological outcrop.

This introduction to geological maps is supplemented by a brief guide to reading a topographic map, a glossary of geological terms, and a profile of sites in the Mount Todd map area that are significant from an Aboriginal perspective.

People are encouraged to apply the knowledge they have acquired from *Record 1998/1* by turning their attention to a range of activities that will test and reinforce their learning skills. No less than ten activities are presented, each of them designed to appeal to those eager not only to extend their scientific understanding but also to equip themselves with skills to be able to apply their learning to a field situation. These activities include 'Finding your way around the map', 'Piecing time, life and rocks together', Special assignment: project prospector', 'Cross sections tell a story', and 'Linking geology with topography'.

Record 1998/1 is a resourceful teaching and learning aid, and will find application in the science faculties with a geoscience component at universities both within and outside Australia. *Record 1998/1* costs $19.95 plus postage and handling charges of $5 (in Australia) or $15 (overseas), and can be purchased from: AGSO Sales Centre, GPO Box 378, Canberra, ACT. 2601.

For more information, contact Gary Lewis, Manager, AGSO Geoscience Awareness Unit on Telephone 02 6249 9570 or E-mail glewis@agso.gov.au

Information from AUS.GEO News No. 45, April 1998.

COMING EVENTS

CAVEPS 99

Papers are invited on any topic of Vertebrate Evolution, Palaeontology or Systematics for the 7th Caveps, to be held at the University of New South Wales, Sydney on April 6 and 7, 1999. Papers are also invited for the special symposium "Evolution, Biogeography and Evolution of Rodents of South East Asia and Australia" to be held April 8 - 10, 1999. Papers may be spoken or poster and the language of the symposium will be English. Abstracts will be required for all papers, spoken and poster, these abstracts must be received by the convenors before March 1, 1999. Abstracts can be submitted in printed form (be sure the letters are clear and dark), or by e-mail, or on 3½ inch floppy disc, when sending

abstracts on floppy disc, Word for Windows is the preferred program but just about any other word processor program can be translated. Both events will be hosted by the Linnean Society of New South Wales.

A post conference excursion will depart Sydney on Sunday, April 11 for three nights in Wellington NSW. Monday, April 12 will be devoted to the Quaternary deposits at Wellington Caves, and on Tuesday the group will go to the Paleozoic fish sites at Canowindra. People wishing to return to Sydney on Wednesday, April 14 may do so; otherwise the tour continues for 3 nights at Lightning Ridge, returning to Sydney on Saturday, April 17. At present the cost of the excursion will be $200 for the Wellington leg (including transport back to Sydney, but not including food) per person, while the cost of the complete trip including Lightening Ridge would be about $450 per person. This is based on two person share motel type accommodation.

CONFERENCE EVENTS

There will be a welcoming BBQ for those attending CAVEPS sessions on Monday evening, April 5, ($10 a head, all inclusive). A dinner for people attending CAVEPS and/or the Rodent Symposium will be held on Wednesday night, April 7, at the Castellorizian (Greek) Club near the University. Cost will be $50 a head.

Inspections of the palaeontological laboratories and other facilities at the University of NSW will be available during the week of the symposium.

REGISTRATION FEES

The fee is $A35 for the CAVEPS sessions, $A45 for the Rodent Symposium, and $A70 for both sessions. Please make cheques payable to the "Linnean Society of New South Wales". Because of the ridiculously high bank charges for cheques in non-Australian currencies, the convenors would prefer people from overseas to make a firm registration but to defer payment until arrival.

For more information on CAVEPS 99 or the Rodent Symposium please contact Michael Augee. Biological Science, University of NSW, Sydney, NSW. 2052. Phone 02 9385 2121, Fax 02 9383 1558. E-mail m.augee@unsw.edu.au

THE GREEN RIVER FORMATION

by Paul Tierney from information supplied in *Paleontology of the Green River Formation, with a Review of the Fish Fauna* by Lance Grande and *Fossils of the Green River Formation* by Stefano Piccini. Pictures of fossil specimens in authors collection.

INTRODUCTION

Located in the states of Utah, Wyoming and Colorado, in the U.S.A., fossil specimens from the Green River Formation are probably some of the most easily recognised fossils from anywhere in the world. The excellent quality with which the majority of the fossil specimens are preserved, especially when prepared by a professional, makes specimens from this formation greatly sort after by private collectors and professional institutions alike. The rich and diversified fossil fauna and flora of the Green River Formation are collected from what were three lakes, Fossil Lake, Lake Gosiute (both found in Wyoming) and Lake Uinta (found in Utah and Colorado). While noted for the fossil fish assemblages, invertebrate fossils like insects, crayfish, prawns, molluscs, plants, worm trails and sponge spicules are also collected, along with vertebrates like crocodiles, stingrays, lizards, snakes (extremely rare), turtles, frogs, birds and bats. There is also evidence (trackways and skeletal remains) that large mammals inhabited the area near the lakes during their existence.

GEOLOGIC HISTORY

The sediments that form the rocks of the Green River Formation were deposited in a mostly lacustrine environment over approximately fifteen million years ranging from the Late Palaeocene through to the late Middle Eocene (from approx. 57 to 42 million years ago). The three lakes lay in a series of intermontane basins that formed during the first uplifting of the Rocky Mountains, these basins filled from the drainage of nearby highlands and eventually contained enough freshwater to support abundant fauna and flora. The large amounts of ash which are found in the sediments indicates that volcanoes were very active periodically throughout the history of the lake system. The Green River Formation is presently 2,100 metres above sea level and covers an area of about 90,000 square kilometres. The fossil flora and fauna indicate that this area was warm temperate to subtropical during the Eocene (Grande, 1984). Annual rainfall was about 92 to 120 centimetres (30 to 40 inches; Bradley, 1929; 1948), with mostly frost free winters. The average annual

minimum temperature was over 2°C (MacGinitie, 1964), and the overall average annual temperature was 15 to 21°C (Grande, 1984).

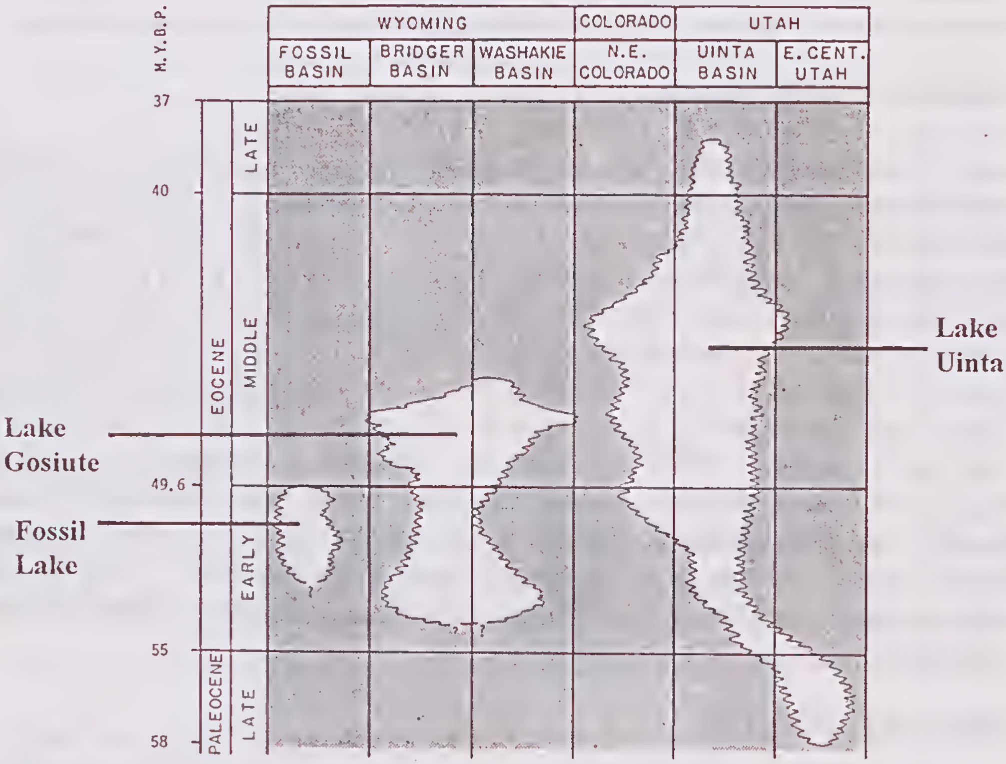

Figure 1. Geographic distribution and approximate duration of the Green River Lakes (after Schaeffer and Mangus, 1965).

FOSSIL LAKE

Occupying the Fossil Basin, Fossil Lake is the smallest of the three lakes and also had the shortest life, confined to the Early Eocene, but it has the honour of being the deepest of the three. Oriel and Tracey (1970) split the Green River Formation of Fossil Basin into two members, the Fossil Butte Member, which is 60 to 80 metres thick near the centre of Fossil Lake, and the overlying Angelo Member, about 60 metres thick near the centre of the lake. The main fish bearing units, the

"18-inch" and "split-fish" layers are to be found in the Fossil Butte Member.

The 18-inch layer is a highly laminated whitish to buff coloured calcite limestone with light to dark brown laminae of fine organic material, the 18-inch layer lies near the top of the Fossil Butte Member and as the name suggests this layer averages about 18 inches (46 centimetres) thick. The laminae may represent annual cycles of deposition and as the 18-inch layer contains about 4000 layers of fine light and dark laminae it is suggested that this represents about 4000 years of deposition. The unit is conformably bordered, above and below, by thin oil shale units, the lowest of which contains abundant plant, insect and molluscan fossils.

Due to its lack of clastic material (analysis indicates a non-carbonate mud, sand and clay content of less than 5%), the 18-inch layer probably represents a deep water area located some distance from shore. The excellent preservation of fossils in the 18-inch layer together with the extreme rarity of bottom dwelling animals such as catfish, stingrays, crayfish and suckers suggests that the lake was chemically or thermally stratified during the deposition of the 18-inch layer.

The split-fish layer is a light coloured limestone and marl and is nearly pure calcite, unlike the 18-inch the split-fish layer is only faintly laminated, or not laminated at all. The unit is mostly about two metres thick and is overlain in some areas by a massive, mollusc rich marlstone. The fact that stingrays and crayfish are more common in this unit than in the 18-inch layer indicates better circulation of bottom waters.

The majority of Green River fossil fish in both private and institutional collections all over the world are from the Fossil Lake area, where they have been commercially quarried since before the turn of the century.

LAKE GOSIUTE

Lake Gosiute existed from the Early Eocene through to the Middle Eocene and occupied the Bridger and Washakie Basins. Lake Gosiute was a broad, shallow lake, currently thought of as a playa lake complex (Eugster and Surdam, 1973; Surdam and Wolfbauer, 1975), there is evidence of fluctuations in the shoreline, and at times the lake became quite saline (Surdam and Wolfbauer, 1975). During

several stages of its history, Lake Gosiute supported thick algal mats over much of its bottom (Surdam and Wolfbauer, 1975) which indicates a possible eutrophic state. Lake Gosiute's eutrophic condition made it more supportive of algae and plants (when compared to modern lakes with the same condition) but not supportive of the large variety of fish species which are found in the deposits of Fossil Lake. Bottom dwelling fish like suckers and catfish were plentiful in Lake Gosiute, however, the average size of fish occupying the upper zones of the lake were smaller than those in Fossil Lake (Grande, 1984).

Most of the fossil fish collected from the Lake Gosiute area have been collected from the Lanley Member, which is Middle Eocene (Bridgerian) in age (Mauger, 1977), with the three main fish bearing rock types of the Lanley Member being the so called "Farson," "Fontenelle," and "Fish-Cut" types. During the period of deposition of the Lanley Member, the lake was at its greatest areal extent (Bradley and Eugster, 1969).

Most of the Farson type material is collected around Farson Dam near Farson, Wyoming and is a grey, tan, orange or red siltstone which is often iron stained. The fossils found in this unit are usually preserved as external casts and impressions and are often the most detailed of any of the fossils to be found in any of the Green River fossil localities.

The Fontenelle type is located near the shores of Fontenelle Reservoir and is a tan to brownish white, muddy, shaley dolomite usual with fine dark brown laminations. The laminations and fossil fish appear similar in colour and preservation to those of the 18-inch layer of Fossil Lake, but the matrix is slightly darker and much harder making preparation of the fossils more tedious. As several plant and insect beds occur in alternating sequence with small fish beds probably indicates that the area dried up and was reflooded several times (Grande, 1984).

The Fish-Cut type is similar to the Fontenelle type in deposition and fossil preservation, but contains many dark, thin, kerogen rich layers.

LAKE UINTA

Lake Uinta, the oldest of the three lakes and the largest, formed during the Late

Palaeocene and persisted through to the late Middle Eocene. During the Late Palaeocene Lake Uinta gradually dried up in the south but expanded east into what is now the Uinta Basin. The sedimentary rock of Lake Uinta represents one of the thickest documented accumulations of lacustrine sediments in the world, with thickness' greater than 2100 metres in places (Cashion, 1967). Despite its large size, Lake Uinta was very shallow during its lifetime, typically, it was lagoonal to shallow lacustrine with many horizons of deltaic deposits, mudstones, shales, sandstones, and siltstones (Baer, 1969). Many zones exhibit mudcracks interbedded with limestones (Baer, 1969) which indicates a fluctuating shoreline. Lake Uinta deposits include vast quantities of high grade oil shale, with oil reserves estimated at 290 thousand million barrels of oil (Cashion, 1967). Although the economic potential of its oil deposits is well known, when compared with the other two lakes, far less is known of its palaeontology. The most frequently collected fossils from the Lake Uinta area are insects and plants with little attention being given to its fossil fish, this is due to the abundance of fish fossils which are found in the other two lakes.

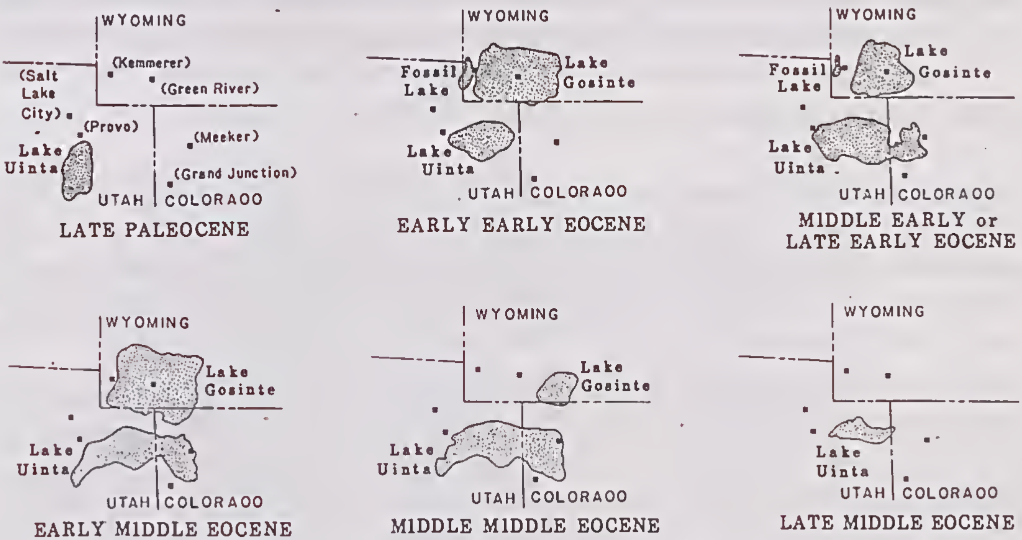

Figure 2. Approximate locations and areas of Lake Uinta, Lake Gosiute and Fossil Lake at different intervals during their history (from McGrew and Casilliano, 1975).

COLLECTING HISTORY

Due to the arrow heads that have been found in the Green River area, it is probably fair to say that the Indians were the first to see the fossil fish of the Green River Formation, what they thought of these fossils is not known and will remain unknown.

The first written records of fossils from the Green River Formation were in various diaries and reports of early missionaries such as S. A. Parker (1840) and explorers such as J. C. Fremont (1845), these were, however, reports on invertebrate fossils. The first fossil fish discovery was made by Dr. John Evans, a geologist, who collected his fish from near what is now Green River, Wyoming. Evans sent his find to Joseph Leidy, in Philadelphia, who identified the fish as a herring, which he named *Clupea humilis* (1856), a name later changed to *Knightia eocaena* Jordon, 1907.

During the summer of 1868, Ferdinand Vandiveer Hayden's expeditions (which led to the establishment of the United States Geological Survey of the Territories) of Wyoming drew his attention to the same area as Evans' discovery and he later named the locality the "Green River Shales" (1869).

During the late 1860's, employees of the Union Pacific Railroad were excavating near Green River, Wyoming (in the area that was Lake Gosiute) when they uncovered the first major fossil fish layer of the Green River Formation. Two employees, A. W. Hilliard and L. E. Ricksecker, were the first to discover the fish and collected many specimens which they turned over to Hayden, Hayden referred to the site where the fish were discovered as the "Petrified Fish Cut" (1871). These specimens were later studied and described by the pioneer vertebrate palaeontologist Edward Drinker Cope in Hayden's 1871 report, the collection consisted of the genera *Knightia*, *Phareodus*, *Erismatopterus* and *Asineops*. During the late 1870's, Cope collected specimens from the Fossil Basin area at what was to be called the "Twin Creek Site" (1884) and described them in several papers (1877, 1878, 1879, 1885 and 1886) and in his classic monograph (1884).

Throughout this time other geologists were reporting additional outcrops of the Green River Formation. In 1876, John W. Powell described sections of the Green

River Formation in the foothills of the Uinta Mountains in northern Utah, and A. C. Peale discovered outcrops of the formation in northwestern Colorado. Both Powell and Peale turned the fossil fish they collected over to Cope for study and description.

Born in Kentucky on February 18, 1866, Robert Lee Craig was probably the first dedicated amateur to dig for fossils in the Green River Formation. Craig started digging in the 18-inch layer of Fossil Lake around 1897 (Powell, 1934) and continued digging in the area for much of the rest of his life. At the age of 28, Craig had one leg amputated as the result of a mine accident, but this never came between him and his true interest in life, that of the Green River fossil fish, which became his main source of income. During mild weather, Craig would climb up to the fossil beds every day in search of specimens, once collected he would then transport them back downhill, in a wheel-barrow, to his summer house (which was an American style wagon). During the winter months he would prepare the specimens, emphasizing their beauty and delicate details and as he was the only person to be doing this sort of work at the time he received mail orders from professional institutions and private collectors for his specimens.

Craig's pioneering work of recovery, preparation and palaeontologic study of the Green River fish was celebrated in July 1997 by the American Association of Paleontological Suppliers (AAPS). In a memorial ceremony held in Kemmerer, Wyoming, the town where Craig is buried, an inscribed gravestone commemorating his contribution to the scientific knowledge of the Green River Formation fossils was placed on his gravesite.

In 1918, David Haddenham joined Craig and the Haddenham family (son David F. and grandson Robert) continued working the area till about 1970. In 1947, Carl and Shirley Ulrich started digging in the area and with their son Wallace, continue to work the area today. Robert Tynsky and his family started working the split-fish layers of Fossil Lake in 1970 and they too continue working the area today.

Craig, the Haddenham family, the Ulrich family, and the Tynsky family have been responsible for the recovery of the majority of Green River vertebrate fossils in public and private collections all over the world.

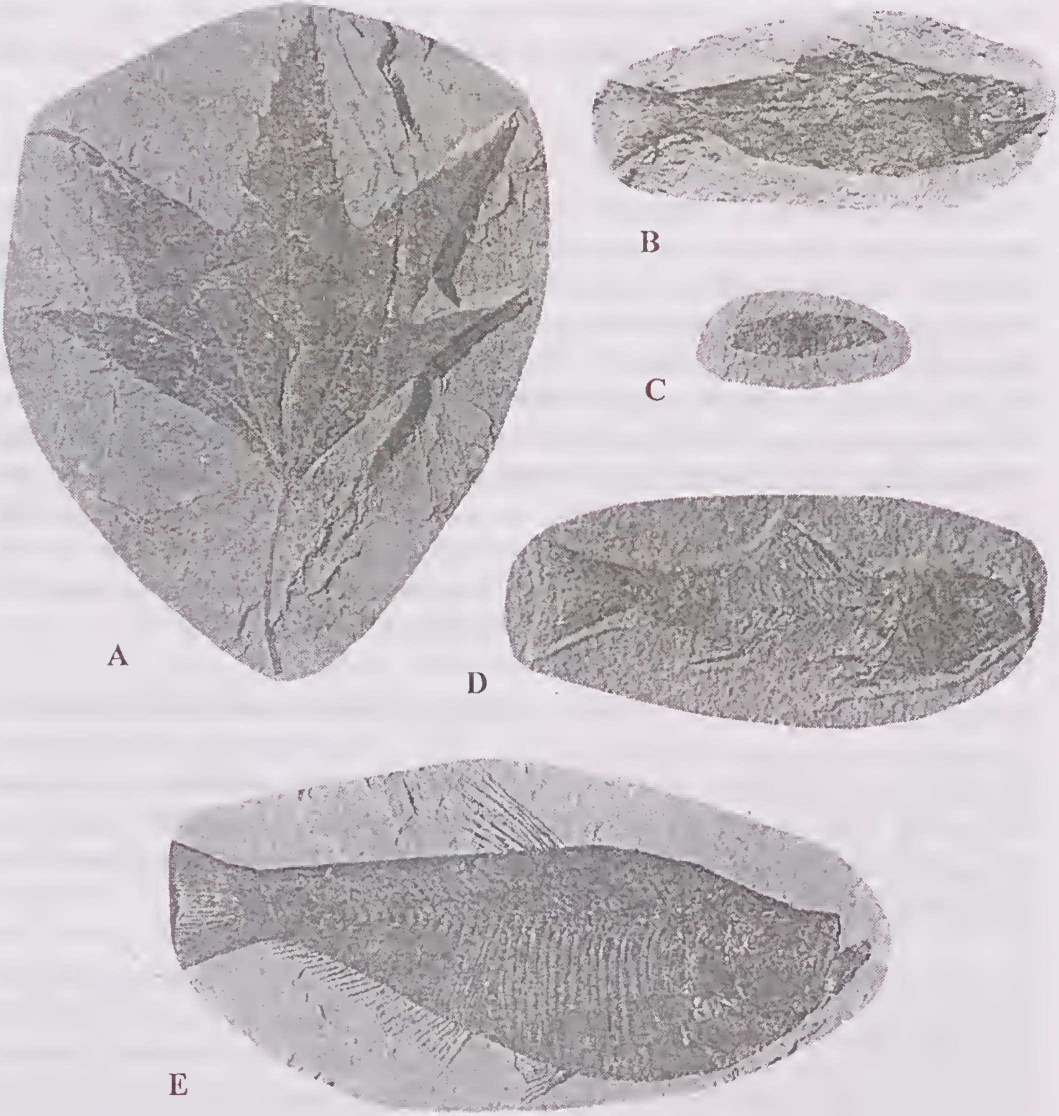

Figure 3. A, *Platanus wyomingensis* MacGinitie 1969 (length 25 cms) from Lake Uinta; B, *Knightia eocaena* Jordan 1907 (length 8 cms) from Lake Gosiute; C, *Ailanthus lesquereuxi* MacGinitie 1969 (length 3.5 cms) fron Fossil Lake; D, *Amphiplaga brachyptera* Cope 1877 (length 11 cms) from Fossil Lake; E, *Diplomystus dentatus* Cope 1877 (length 14 cms) from Fossil Lake.

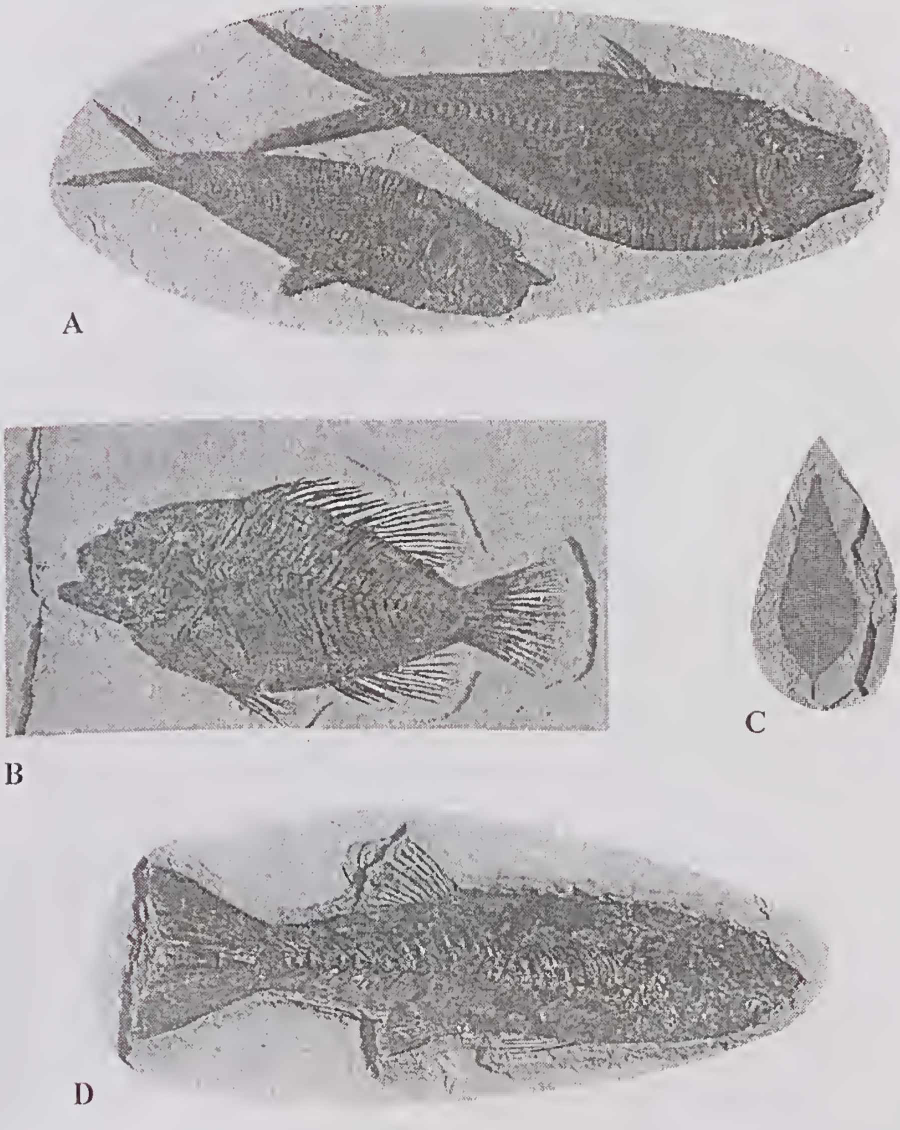

Figure 4. A, *Diplomystus dentatus* Cope 1877 (length of largest specimen 15 cms) a pair from Fossil Lake; B, *Priscacara serrata* Cope 1877 (length 11 cms) from Fossil Lake; C, *Styrax transversa* MacGinitie 1969 (length 7 cms) from Lake Uinta; D, *Mioplosus labracoides* Cope 1877 (length 14 cms) from Fossil Lake .

FINANCES

Income and expenditure for the twelve months, July 1, 1997 to June 30, 1998. The previous twelve months income and expenditure (July 1, 1996 to June 30, 1997) is shown in brackets

<u>INCOME</u>

Subscriptions		
current	774.00	(1,075.50)
advance	672.50	(900.20)
Donations	18.68	(19.25)
Advertising	—	—
Bank Interest	2.73	(87.31)
Sale of Bulletins	109.00	(140.00)
	$1,576.91	(2,222.26)

<u>EXPENDITURE</u>

Postage	763.91	(672.35)
Printing	595.92	(651.49)
Photocopies, photo's & bromides	252.50	(75.15)
Stationery	127.86	(110.99)
Sundries	35.36	(35.67)
Secretarial expenses	23.37	(166.27)
Subscriptions	—	(38.30)
State/Federal tax	7.50	(7.88)
	$1,806.42	(1,758.10)

<u>Balance at June 30, 1998.</u>

Brought forward from	1996/1997	$2,587.50
Add income	1997/1998	<u>$1,576.91</u>
		$4,164.41
Less expenditure	1997/1998	<u>$1,806.42</u>
		$2,357.99

When the 1997/98 income is adjusted to include subscriptions paid in 1995/96 and 1996/97 ($861.00) and to exclude 1998/99 1999/2000 subscriptions ($672.50), expenditure for the financial year 1997/98 exceeded income by $41.01, compared with a surplus of $148.94 for the previous year. After deducting total advance subscriptions from the balance in hand at June 30, 1998, we are left with a **NET RESERVE OF $1,676.49** ($1,687.30).

Assets are valued at approximately $1,600 (these include part ownership of a word processor [50%], stationery, staplers and back issues of Bulletins etc.). At June 30, 1998, there were no liabilities.